MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2015 / 2016

PGC0225 – GENERAL CHEMISTRY

(Foundation in Life Sciences students only)

12 MARCH 2016
2.30 p.m. – 4.30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of **6** pages only excluding the cover page.
2. Answer any **FIVE** out of **SIX** questions.
3. Please write all your answers in the answer booklet provided.
4. Distribution of marks for each section / question is given.

STRUCTURED QUESTIONS [50 MARKS]

Instruction: Answer any **FIVE** out of **SIX** questions.

Question 1 [10 marks]

a. The explosion of *nitroglycerin* ($C_3H_5N_3O_9$) can be represented by the following equation below. (*Atomic mass*: O = 16.00; N = 14.01; H = 1.00; C = 12.01)

$$4\,C_3H_5N_3O_9\,(l) \rightarrow 6\,N_2\,(g) + 10\,H_2O\,(g) + 12\,CO_2\,(g) + O_2\,(g)$$

Based on the information provided above, answer the following:

(i) *Theoretically*, how many grams of oxygen gas can be produced from the explosion of 681.3 grams of *nitroglycerin*? (1 mark)

(ii) If 15.0 grams of oxygen gas was produced from the explosion of 681.3 grams of *nitroglycerin*, what is the estimated *percent yield*? (½ mark)

(iii) *Theoretically*, how many grams of *total products* (N_2, H_2O, CO_2 and O_2 combined) can be obtained if exactly 1.0 mole of *nitroglycerin* is exploded? (1½ mark)

(iv) *Theoretically*, how many grams of *nitroglycerin* must be exploded if 1.0 gram of nitrogen gas (N_2) is required to be produced? (1 mark)

b. Answer the following questions which are based on chemical reactions.

(i) What do you understand by the term "*precipitation*"? (1 mark)

(ii) What is the *final concentration* of a mixture made up of 75 mL of 0.18 M H_2SO_4 and 250 mL of 0.018 M H_2SO_4 that have been evenly mixed together? (2 marks)

c. Refer to **Figure 1**. Based on the *electrochemical series*, write a *balanced* equation for the chemical reaction (*if any*) in each of the following. (3 × 1 mark)

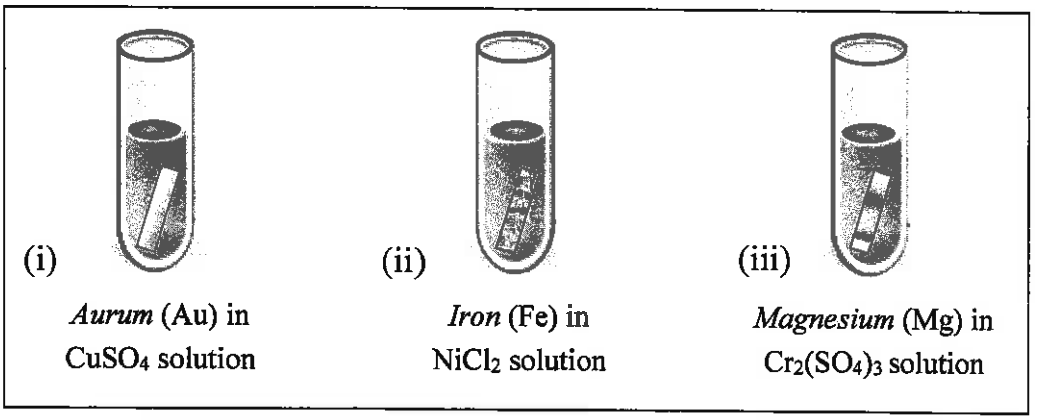


Figure 1

Continued...

Question 2 [10 marks]

a. Use ***Hess's Law*** to calculate the *heat of reaction* ($\Delta H°_{rxn}$) for the reaction below:

$$4\,NH_3\,(g) + 5\,O_2\,(g) \rightarrow 4\,NO\,(g) + 6\,H_2O\,(g)$$

You are given the following *balanced* thermochemical equations:

$N_2\,(g) + 3\,H_2\,(g) \rightarrow 2\,NH_3\,(g)$	$\Delta H°_{rxn} = -91.8$ kJ
$N_2\,(g) + O_2\,(g) \rightarrow 2\,NO\,(g)$	$\Delta H°_{rxn} = 180.6$ kJ
$H_2\,(g) + \frac{1}{2}\,O_2\,(g) \rightarrow H_2O\,(g)$	$\Delta H°_{rxn} = -241.85$ kJ

(*Note: calculation steps must be shown where applicable*). (3 marks)

b. Briefly explain the difference between each of the following terms.

(i) *Dispersion forces* and *dipole-dipole forces*. (1 mark)

(ii) A *crystalline solid* and an *amorphous solid*. (1 mark)

c. **Figure 2** is a *phase diagram* for "*X*". Based on **Figure 2**, answer the following.

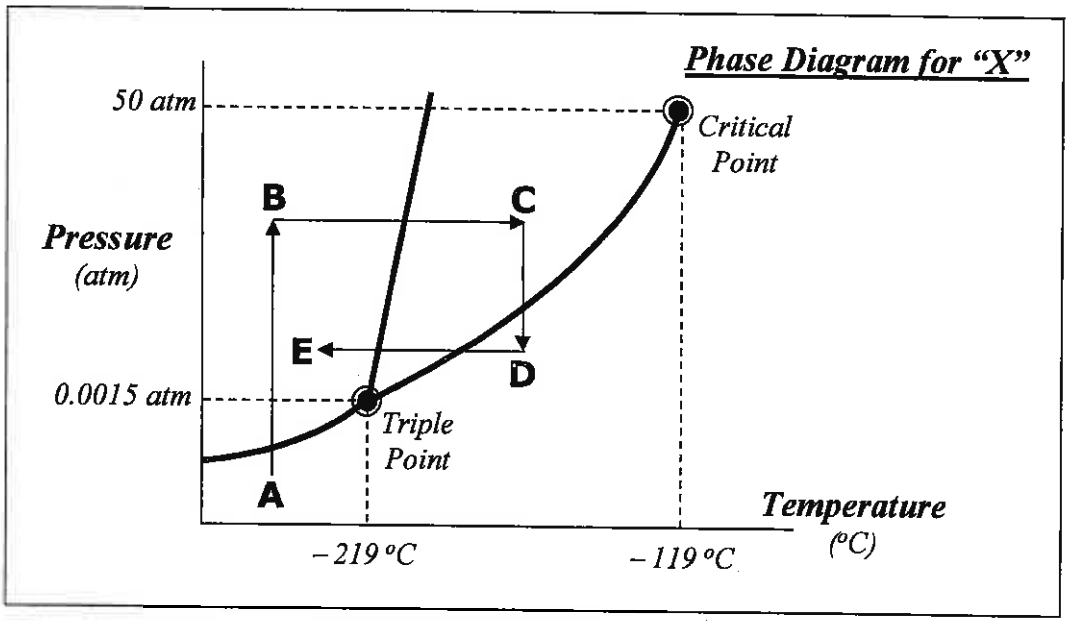


Figure 2

(i) Describe the changes in phase, pressure or temperature and state the names of the processes that take place for a sample of "*X*" (in a sealed container) that undergoes the indicated changes from **A** to **B**, **B** to **C**, **C** to **D** and **D** to **E**. (4 marks)

(ii) What is the difference between *triple point* and *critical point*? (1 mark)

Continued...

Question 3 [10 marks]

a. **Figure 3** below indicates the position of 6 unnamed elements in the periodic table. These 6 elements have been labeled ***O***, ***P***, ***Q***, ***R***, ***S*** and ***T***.

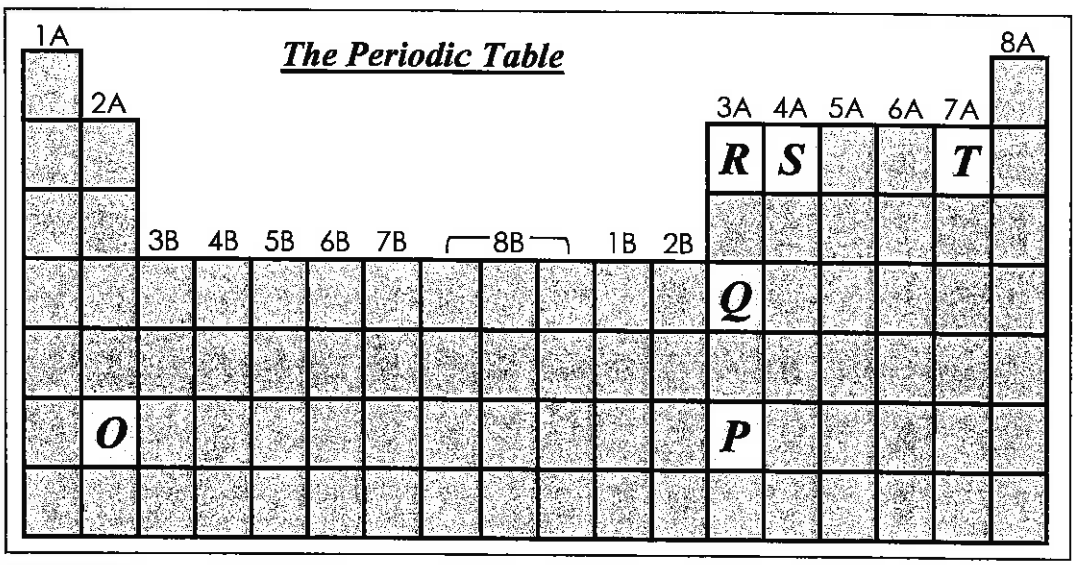


Figure 3

Based on the information given in **Figure 3**, answer the following.

(i) Arrange the 6 elements in terms of their *atomic radii* in an *increasing* order. Begin with the element which has the smallest *atomic radius*. (1 mark)

(ii) Which of the 6 elements is likely to have the *largest ionic radius* when all the 6 elements above form their respective ions? (1 mark)

(iii) Predict the *molecular formula* of the compound made up of '***R***' and '***T***'. (1 mark)

(iv) Briefly explain why is it that the *atomic radii* of the elements generally *decrease* across a period? (1 mark)

b. Calculate the wavelength (nm) of a photon emitted by a hydrogen atom when its electron drops from $n = 4$ state to $n = 3$ state. (2 marks)
($R_H = 2.18 \times 10^{-18}$ J ; $h = 6.63 \times 10^{-34}$ J.s)

c. Write the *ground state electron configurations* for the *ions* of the elements below:

(i) *Cobalt* (*symbol* = Co; *atomic number* = 27; *transition metal*) (1 mark)

(ii) *Bromine* (*symbol* = Br; *atomic number* = 35) (1 mark)

d. What does it mean when we say that two ions are "*isoelectronic*"? (1 mark)
Provide any 2 examples of a pair of *isoelectronic ions*. (2 × ½ mark)

Continued...

Question 4 [10 marks]

a. *Electronegativity* is distinguishable from *electron affinity* and is a relative quality. The element with the highest electronegativity in the periodic table is fluorine. Based on this information, answer the following.

(i) Briefly explain the term *electronegativity*. (1 mark)

(ii) What is the primary role of *electronegativity* in determining the relationship among *nonpolar covalent bonding*, *polar covalent bonding* and *ionic bonding*? Explain with specific examples of Cl_2 (*nonpolar covalent bonding*), HCl (*polar covalent bonding*) and NaCl (*ionic bonding*). (3 marks)

b. Draw the *Lewis structures* and state the total number of *valence electrons* for each of the following examples:

(i) *Ammonia* (NH_3) (1 mark)

(ii) *Nitrate ion* (NO_3^-) (1 mark)

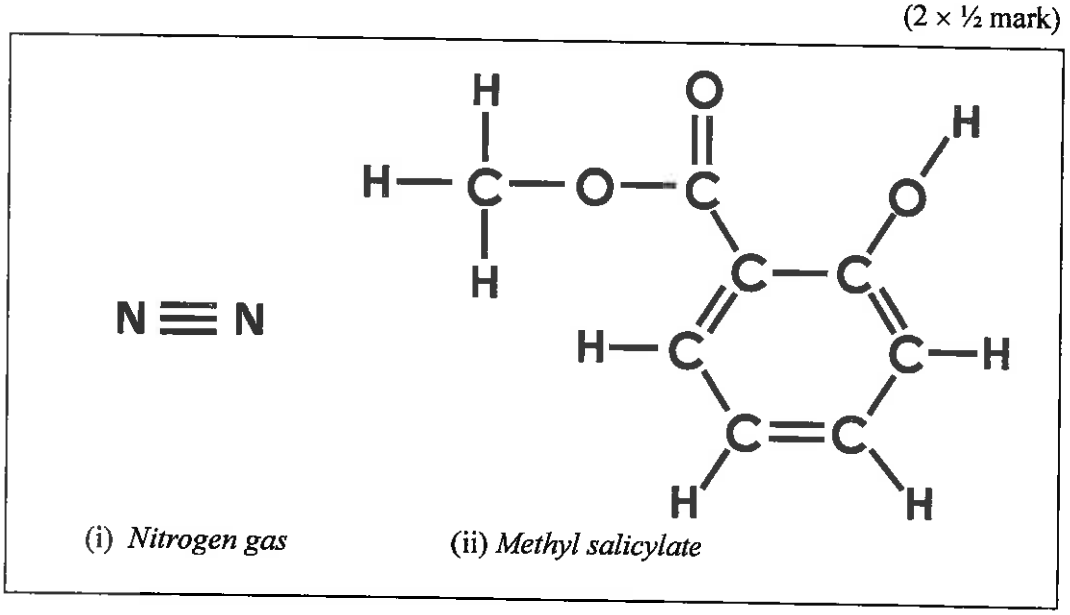
(iii) *Nitrosyl fluoride* (NOF) (1 mark)

c. Name the shape (*molecular geometry*) and give the AB_mE_n classification for the following examples:

(i) *Perchlorate ion* (ClO_4^-) (1 mark)

(ii) *Iodine pentafluoride* (IF_5) (1 mark)

d. **Figure 4** below depicts the molecular structures of 2 different molecules. Based on these structures, deduce the number of *sigma* (σ) and *pi* (π) bonds in each molecule. (2 × ½ mark)



(i) *Nitrogen gas* (ii) *Methyl salicylate*

Figure 4

Continued...

Question 5 [10 marks]

a. **Table 1** contains the initial concentrations of the reactants for the chemical reaction between *bromate* and *bromide* ions in acid solution (shown below in a balanced equation) and the initial reaction rates for 4 trials at constant temperature.

$$BrO_3^-\,(aq) + 5\,Br^-\,(aq) + 6\,H^+\,(aq) \rightarrow 3\,Br_2\,(l) + 3\,H_2O\,(l)$$

Trials	$[BrO_3^-]_o$ (M)	$[Br^-]_o$ (M)	$[H^+]_o$ (M)	Initial reaction rates ($M.s^{-1}$)
Trial 1	0.10	0.10	0.10	8.0×10^{-4}
Trial 2	0.20	0.10	0.10	1.6×10^{-3}
Trial 3	0.20	0.20	0.10	3.2×10^{-3}
Trial 4	0.10	0.10	0.20	3.2×10^{-3}

Table 1

Based on the information provided in **Table 1**, answer the following.

(i) Determine the *rate law*. (4 marks)

(ii) Determine the *rate constant*. (*Note*: *the correct unit must be provided*). (½ mark)

(iii) Suppose a 5th trial is run and $[BrO_3^-] = 0.15$ M, $[Br^-] = 0.15$ M and $[H^+] = 0.15$ M. What is the initial rate of reaction in this 5th trial? (½ mark)

b. *Ethanal* (CH_3CHO) decomposes by a *second order* reaction into *methane gas* (CH_4) and *carbon monoxide gas* (CO) according to the following chemical equation:

$$CH_3CHO\,(g) \rightarrow CH_4\,(g) + CO\,(g)$$

The rate of *decomposition* of *ethanal* is 0.10 $M.s^{-1}$ when the concentration of *ethanal* is 0.10 M. Based on this information, answer the following.

(i) Write the *rate law* for this reaction. (1 mark)

(ii) Determine the *rate constant*, *k*. Provide the correct units for *k*. (1 mark)

(iii) Find the rate of *decomposition* if the concentration of *ethanal* is 0.5 M. (1 mark)

c. For a reaction with a single reactant of "G", sketch a graph for a *first order* reaction with the labeled axes of ln [G] versus *t*, and provide the corresponding equation containing $\ln[G]_t$, $\ln[G]_0$ and *t*. Explain how the *rate constant*, *k*, can be determined from the graph that you have sketched. (2 × 1 mark)

Continued...

Question 6 [10 marks]

a. A synthesized compound which is weakly acidic in water, is made up of chemical molecules called HY. A 0.089 M solution of HY was observed to have a pH of 5.78. In fully characterizing the properties of this new compound, the K_a value for it can be determined. Based on this information, answer the following.

(i) Determine the K_a value for this compound. (2 marks)

(ii) Find the percentage of *dissociation* (or *ionization*) for this compound. (1 mark)

(iii) What is K_a? Explain. What does the K_a value indicate? (2 × ½ mark)

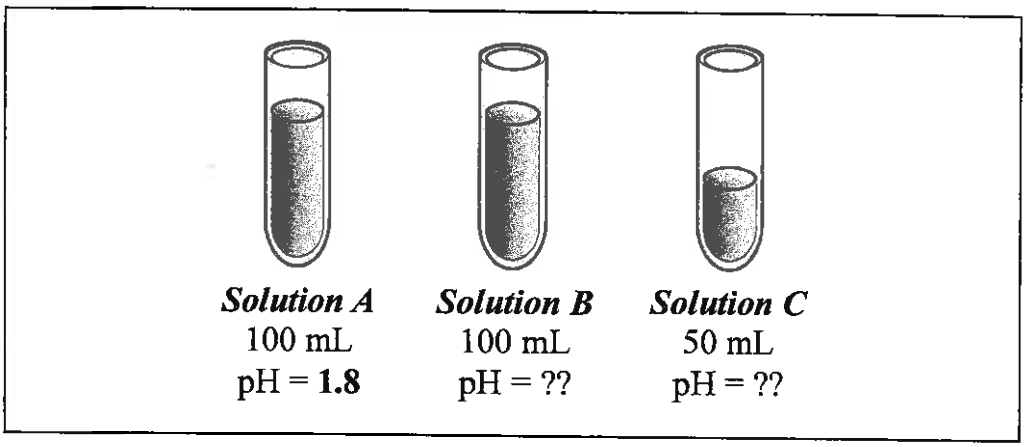


Figure 5

b. **Figure 5** is a diagram of three test tubes of HCl (*hydrochloric acid*) with different amounts of H^+ ions, respectively called *solution A*, *solution B* and *solution C*. *Solution A* and *solution B* have the same volume of 100 mL each but different pH values. It is known that the pH of *solution A* is **1.8**. It is also known that *solution A* contains 1000 times more H^+ ions as compared to *solution B*. It is also known that *solution C* contains the number of H^+ ions of *solution A* and *solution B* combined but has a volume of only 50 mL. Based on this information, answer the following.

(i) What is the pH of *solution B*? (2 marks)

(ii) What is the pH of *solution C*? (2 marks)

c. The following two chemical reactions are important environmental processes. Identify the 2 *conjugate acid-base pairs* for each chemical reaction and state the ***acid*** and ***base*** for each *conjugate acid-base pair.*

(i) $H_2PO_4^-\,(aq) + CO_3^{2-}\,(aq) \rightleftharpoons HCO_3^-\,(aq) + HPO_4^{2-}\,(aq)$ (1 mark)

(ii) $H_2O\,(l) + SO_3^{2-}\,(aq) \rightleftharpoons OH^-\,(aq) + HSO_3^-\,(aq)$ (1 mark)

End of paper